Bell Laboratories Record

Volume Three NOVEMBER, 1926 *Number Three*

Reducing the Cost of Electrons

By WILLIAM WILSON

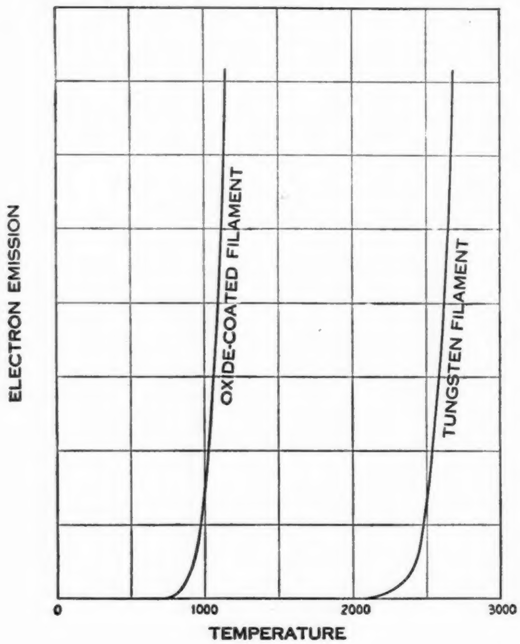
IN a vacuum tube perhaps the most important and certainly the most troublesome element is the filament. The purpose of the filament is to emit electrons, or small particles of negative electricity, which are drawn across to the plate and form the space current.

To insure proper operation of a vacuum tube it is necessary to maintain the filament at a sufficiently high temperature to provide an adequate electron emission. This involves a consumption of energy which is one of the main items of expense in vacuum-tube operation. The electron emission from the filament rises very much more rapidly with temperature than does the power required to heat the filament. Hence it is desirable to run the filament at as high a temperature as possible. Another important item in vacuum-tube expense is the cost of tube replacement, which involves the initial cost of the tube and its life. The life of a vacuum tube decreases very rapidly as the filament temperature is raised. Hence, from this standpoint, it is desirable to run the filament at as low a temperature as possible. The filament in a commercial tube should be operated at such a temperature that the annual charge, taking both these factors into consideration, is a minimum.

Our knowledge of electron-emission phenomena runs back to 1733, nearly one hundred years before the discovery of the electric current. At that time DuFay observed that a hot body loses an electric charge more rapidly than a cold one. During the next 170 years a large number of more or less relevant observations were accumulated but an adequate explanation of the phenomenon was not forthcoming until after the development of the modern electron theory.

In 1901 Richardson derived a theoretical expression connecting electron emission and temperature, and showed that it was in excellent accord with the experimental data. His theory assumes that inside a conductor a certain number of electrons are free to move about with an average energy proportional to the temperature—in a manner similar to the way in which the molecules of a gas are supposed to move about in space. It further as-

sumes that at the surface of the conductor there is an electric field tending to keep the electrons from escaping into free space. Although the electrons have a definite average energy, any single electron may have a velocity much greater or much less than the average, and some electrons should reach the surface with a sufficient velocity to escape in spite of the adverse surface forces. It was by calculating the number of electrons which should arrive at the surface with sufficient velocity to escape, that Richardson derived the laws connecting electron emission and temperature.



Electron emission and temperature

The electrons which leave the filament do so against the influence of an adverse electric field and hence must do a certain amount of work in leaving the surface. This quantity is known as the "work function" and varies with the substance. The lower the work function the smaller the velocity an electron must have in order to leave the surface; and hence at the same temperature substances with low work functions emit electrons more copiously than those with high ones. This is illustrated by the accompanying graph for tungsten and for the oxide-coated filaments used in the telephone plant. The latter have a much lower work function than tungsten.

At the time the vacuum-tube repeater was introduced in the Bell System telephone plant there were two classes of electron emitters suitable for vacuum-tube filaments. On the one hand there were the refractory metals such as tungsten, molybdenum, tantalum and osmium, all of which have rather high work functions but can be operated at such high temperatures that a copious supply of electrons may be obtained at reasonable cost. Of these the most suitable was tungsten. On the other hand, there were the Wehnelt cathodes which consist of the oxides of the alkaline earth metals coated on a platinum base. They cannot be operated at such high temperatures as tungsten, but have much lower work-functions. At the time we are considering, they were very erratic with regard to their life and exceedingly difficult to reproduce from the standpoint of activity. They offered, however, considerable advantages from the operating standpoint and an effort was made to make them sufficiently stable for commercial use.

By the time the transcontinental telephone line was opened in 1914 our development had advanced to the stage where it was possible to equip the repeaters on this line with tubes containing oxide-coated filaments, which were sufficiently stable for commercial operation, and on which the

annual charges were only about one-half of what they would have been if tubes containing tungsten filaments had been employed. These tubes consumed about nine watts in the filament and had a life of less than one thousand hours, which involved annual charges for filament power and tube replacement of about one hundred dollars per tube socket.

It was recognized that the uses of vacuum tubes in the telephone plant would be considerably extended, and that new projects involving them would be greatly hampered unless the annual operating charges were materially reduced. A comprehensive program was therefore undertaken which, with modifications and ramifications is still in progress.

Our investigations have led us very far afield. At one end of the scale we have worked on such abstruse theoretical studies as the nature of the surface forces which hold the electrons in the filamentary material, on the reflection of electrons from solid surfaces and on the distribution of the velocities of the emitted electrons. These studies have not only led us to a better understanding of the phenomena involved, but have enabled us to bring the best possible theoretical considerations to our more practical problems and have shed some light on the general problems of modern physics.

At the other end of the scale we have concerned ourselves with the more practical aspects of the problem. The methods of preparation of the filament materials and of coating have been standardized. Effects of impurities in the filament materials have been investigated and it has been found necessary to use very pure materials not only in the coating but also in the core. As a matter of fact the platinum from which our filament-ribbon material is made is probably the purest used in any commercial undertaking. Other work has involved development and standardization of pumping methods, for the activity and life of the filament are greatly affected by the treatment it receives during the evacuation process.

In addition we have not confined our attention to oxide-coated filaments alone but have made a general survey of the thermionic properties of all available refractory substances and have made thorough investigations of some which showed promise of commercial value.

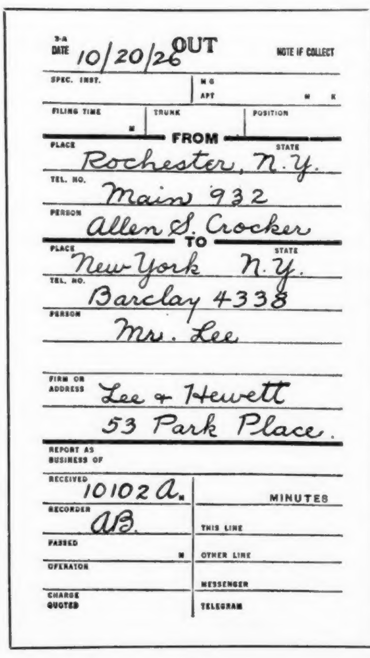
These various lines of attack have been so dovetailed together that it is almost impossible to evaluate the contribution of any specific one to the art of filament manufacture. The whole investigation has, however, led to very great improvements in filament quality. The tubes now in use in the plant have a power expenditure of only four watts in the filament, or less than half that of the original tubes, and are engineered on a much more conservative basis from the standpoint of available electron emission. More recent developments have led to a further reduction in the filament power; and a tube has been designed and tested in the laboratory in which this power is further reduced to about two watts. At the same time the average life of the tube has been very greatly increased. The present tubes have an average life of at least 20,000 hours and probably of about 100,000 hours. The exact figures are not known, since it takes time to make the tests and a year is less than 9,000 hours.

Mechanical Distribution of Toll Tickets

By CHARLES L. VAN INWAGEN

IN twenty years the population of the United States has increased thirty percent, while telephone traffic over Long Lines of the Bell System has increased five hundred percent. Growth at this rate evidences the public's recognition of long-distance telephony as an effective and prompt means of communication; in fact, its speed is one of its greatest recommendations to the user. Of assistance in reducing the time required to establish a long-distance call is the new mechanical system for distributing tickets in toll and long-distance offices.

A toll ticket—the record of details as to telephone calling and called, time of conversation, and amount charged for the service—is written for every toll call. When the call is handled at a toll switchboard, economical use of costly circuits dictates that the record be complete in detail. These tickets are handled by two or more operators. For example, you inform your local operator that you wish to make a toll call. She replies, "I will give you Long Distance"; and next you hear an operator in the Toll Office. This operator sits at the "recording board" which consists of one or more low-type switchboard sections with trunks from the local offices in the district. One of her duties is to make out a "toll ticket" as shown on the accompanying illustration. On it she writes all the information you can give her regarding the called party's name, address, and telephone number, as well as the same data regarding yourself. If you cannot give complete information, the ticket must be referred to a directory operator who, from a file of directories covering cities and towns which are most likely to be called, adds the information required. The ticket is then sent to the outward-line operator who secures the connection with the called party. She stamps the time on the back of the ticket when your conversation begins and again when you are through. Then she sends it to the ticket-filing operator, who holds it until it is wanted for billing purposes.


S-A DATE 10/20/26 OUT NOTE IF COLLECT
SPEC. INST. NO APT
FILING TIME TRUNK POSITION
FROM
PLACE Rochester, N.Y. STATE
TEL. NO. Main 932
PERSON Allen S. Crocker
TO
PLACE New York N.Y. STATE
TEL. NO. Barclay 4338
PERSON Mrs. Lee
FIRM OR ADDRESS Lee + Hewett
53 Park Place.
REPORT AS BUSINESS OF
RECEIVED 10102 a. MINUTES
RECORDER AB. THIS LINE
PASSED OTHER LINE
OPERATOR MESSENGER
CHARGE QUOTED TELEGRAM

A typical toll-ticket, reduced from 2½ by 5 inches

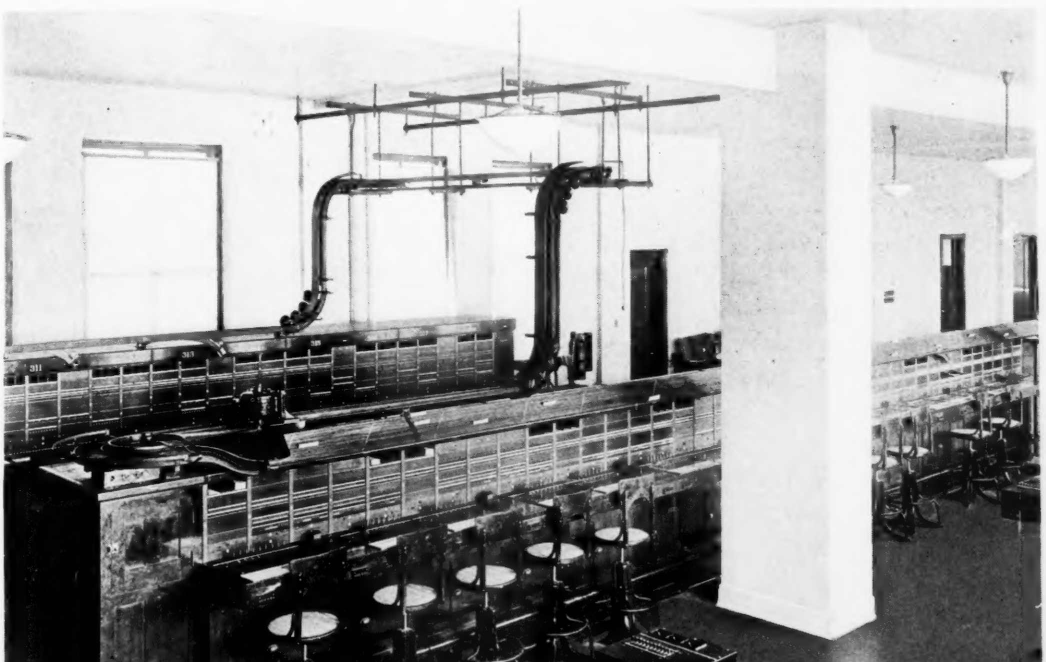
In the small offices, toll tickets are distributed by messengers. In larger offices the need for a more orderly and efficient method of handling tickets was recognized twenty years or

more ago, when the present toll offices were installed in the larger cities. At that time, the pneumatic system for ticket distribution was developed. In the meantime many small offices have outgrown distribution by messengers; but for them the cost of a pneumatic system, plus that for the necessary alterations in the switchboard equipment, would be prohibitive.

Accordingly there was recently developed a distributing-system which can be adapted to existing offices without the necessity of making extensive changes in the layout of present equipment. Its general requirements included an adaptability which should permit the easy dispatch of tickets from any recording or directory operator to any outward-line operator, and the return of completed tickets to the filing desk.

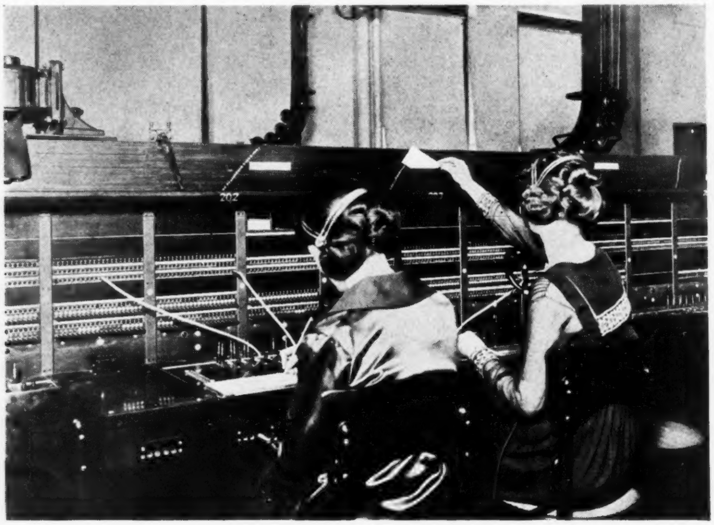
The system comprises a group of slots mounted side by side into any of which a ticket may be placed on edge; a car with a projecting finger to push the tickets along the slots; and a means for propelling and guiding the car.

These slots, called "ticket guides," are "U" shaped channels of sheet brass. The guides are supported by a sheet-iron channel, on one flange of which is mounted a track for the car. The channel, together with the track



The mechanical system as installed at Omaha. In the foreground, the recording board: behind it, a part of the outward line board. Note the overhead crossing

which is mounted on it, is arranged so that the cars may travel continuously around the system. A round leather belt which pulls the cars passes over idler pulleys; these are mounted on the brackets which support the channels.



A close-up of the Omaha recording-board as an operator starts a ticket on its way

It was necessary to mount this system without interfering with existing equipment; and the roof of the switchboard was chosen. Since usually the recording-operator is at a low switchboard and the outward-line operator is at one which is higher and which is generally located on the other side of the room, it was necessary to arrange the system to carry tickets from one level to another and overhead across the room.

At the recording board the ticket guides are banked in steps sloping down toward the front of the board. Each guide is numbered to correspond with the outward-line position which it serves; and the recording operator has only to select the proper guide and insert the ticket.

At the inward—and outward—line positions, the ticket guides are arranged in a horizontal plane; both flanges of these "flat" guides are of the same height. As each guide reaches its outward-line position it terminates in a receiving chute in front of the center panel of the section.

The system is also used to carry completed tickets from the line operators to the filing desk. At high-type line sections, a hoist elevates the ticket to a position where the car will push it into the common-return guide and carry it to a receiving chute at the ticket-filing desk. This hoist is a length of guide hinged where it connects with a spur leading into the return guide. By an arrangement of levers and a cam, the weight of the hoist is

A line operator places the completed ticket in the hoist

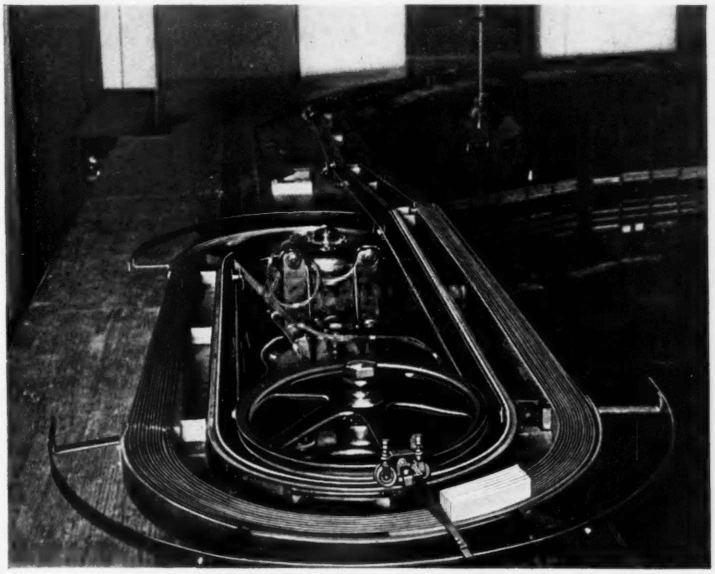
balanced by the tension of a spring. The operator's slight pull, or push, on a lever causes the hoist to go down or up at a moderate speed.

At points where tickets are carried from one level to another, metal guards placed over the guides keep the tickets from falling out. The height of a rise or drop is not limited to differences in the height of the switchboards. In one installation, the system carries tickets from recording operators to outward-line operators on the floor above.

The track on which the car runs is made from the best grade of leather belting screwed to the channel as shown in the picture. At horizontal corners, the track is reinforced on the sides by thin strips of spring steel to prevent the thrust of the car wheels from wearing the leather itself.

The car has three flanged wheels mounted on the smallest commercial ball-bearings obtainable. The two upper wheels are mounted in yokes which pivot as the car turns corners. A link with a double-ended ball socket attaches the car to the driving belt. The belt is divided into equal sections about forty feet long, each end of which is equipped with a ball-ended terminal which fits into the ball-socket on the end of the car link. This elaborate connection is necessary because a round belt has a habit of rotating when moving around pulleys and if prevented from rotating by a rigid connection, it has a tendency to kink and sometimes to run off the pulleys.

On the side of the car is mounted the ticket pusher, a smooth metal finger which normally projects horizontally over the guides and clears them by about one-eighth inch. The tickets themselves project about seven-eighths inch above the guides. At the recording board, where guides are banked down from the track, the angle is about forty degrees. In order that the ticket pusher may function here, it is hinged so that it can swing down to this angle. At a transition point, a fibre cam is attached to the outer edge of the guard over the guides and it deflects the ticket pusher so that it will engage with the tickets.



A driving unit in a straight run. Note a car taking its tickets around the corner

If an operator is placing a ticket in the guide when a car is coming and the ticket pusher should strike her hand, the pusher merely folds back on a vertical pivot and slips past her hand. The pivot permits the pusher to move horizontally against the tension of a spring which normally holds it at a right angle with the direction

in which the system runs. When it strikes something it disengages with the rail which holds it down at the banked section. Any tickets which it has been pushing along the lower guides will be left behind for the next car to pick up.

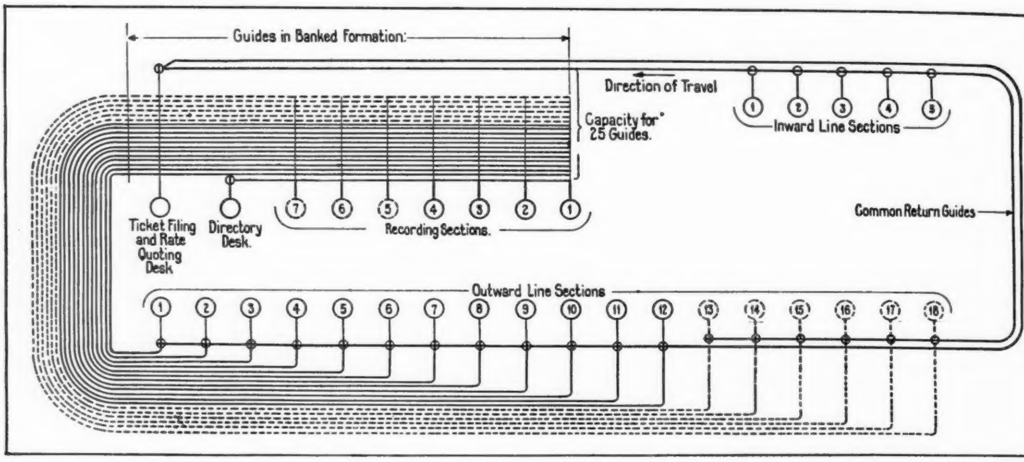
The speed for the cars, about 300 feet per minute, was selected after trial and consideration of reliability maintenance and wear of parts, and noise. The shape, for example, of the downward bend in the receiving chute depends to a considerable extent on the speed; this particular bend is a curve approximating a parabola.

Most of the pulleys are grooved and designed with liberal flanges, and all are on ball bearings. On one type of horizontal corner, a special type of idler pulley is required since the belt is on the convex side of the corner. These "split" pulleys are used in pairs and are assembled with their axes at an angle to each other and with a space between so that the belt will bear on the face of each pulley and yet allow the link which attaches the car to slip through the gap.

Noise presented a problem in the development of this system. Many experiments with different combinations of material for the car wheels and track resulted in the selection of leather track and steel wheels and in methods for mounting so as to reduce the soundboard effect of the wooden switchboard-roofs.

Motive power for the belt is obtained from motors which are belted to large double-grooved pulleys at those corners where the system is turned through an angle of 180 degrees. To drive without unduly straining the round leather belt requires that the motors shall be spaced not more than one hundred feet apart. In laying out a system, therefore, particular attention has to be paid to providing 180 degree corners at suitable intervals since it was found that ninety degrees of contact with the belt was not adequate without spacing the motors closer together. Whenever practicable motors are placed at the ends of the switchboard where the system usually turns to cross the room. A double-loop corner is used when the switchboard is so long that two driving points are needed.

The mechanical system is not necessarily restricted to small offices.



A typical layout: dotted lines indicate provision for growth

Although its maximum capacity is twenty-three outward-line sections, two installations have already been made where it serves a larger number; but in these cases, two separate mechanical systems have been installed. These were arranged so that one, mounted on the recording board, delivers tickets to a combined directory and distributing desk on which are mounted the banked guides of the second system. The recording operator when she has a ticket for a position located on the second system, sends this ticket to the distributing desk where it is relayed by the second system. Both end at the filing-desk so completed tickets can be returned.

At present systems of this design are helping to speed up the toll traffic in many centers, including Omaha, Salt Lake City, Akron, Nashville, Baltimore, Kansas City, Seattle, Rochester, and New Orleans.

Front and back pages of the passport issued to Mr. E. B. Craft in 1918 while as technical advisor to the United States Navy he was on a War mission. The signatures of Secretary Lansing and Ambassador Page are easily recognized. Like other passports of that period it was filed after cancellation in Washington. Its release from the archives was recently obtained by Lieutenant Commander Robert A. Lavender who sent it to Mr. Craft as a souvenir of their association at that time.

A Mechanical Brain

TESTING brains is a favorite amusement of many psychologists, and most of us have been subjected to such tests. One much-used test requires the subject to run his eye along row after row of closely printed figures or letters and to strike out with his pencil some particular figure or letter as often as it occurs. "Mark every 9 which is not preceded by 5" is a typical instruction, and the speed and accuracy with which one performs is taken as some indication of his intelligence.

While the psychologists are busy testing human brains, engineers—particularly certain groups of electrical and mechanical engineers — are engaged in devising mechanical brains and subjecting them to "intelligence tests." The intelligence of a brain is measured by its ability to get an idea and respond to it. There are no brains in the gear-shifting mechanism of an automobile; it does not receive the idea of the driver and then act accordingly—it is merely shoved about. But the name of a "mechanical brain" might well dignify a piece of apparatus which can get the idea that it is to run over row after row of numbers and select in each row a particular number. To get such an idea and then to do it at the rate of about sixty numbers a second means some brains somwhere, even if strictly speaking they must be credited to the systems and apparatus engineers who devised it rather than to the apparatus itself.

The brain in the panel-type machine-switching telephone system is called "the sender" because, after learning the number desired by a subscriber, it sends out the controlling impulses which obtain for him the proper telephone line. It is the mechanical operator to whom he indicates his wish; and its attention is secured by taking the telephone receiver off its hook.

Lifting a receiver from its hook attracts the attention of the telephone operator in a manual-telephone system by lighting on the switchboard a lamp adjacent to the terminal of the subscriber's line. To answer she picks up an idle cord,* inserts its plug into the jack indicated by the lamp, and by a key switches her talking equipment into a network of supervisory and signalling apparatus which constitutes the so-called "cord circuit." By "Number please?", she announces her readiness for instructions. The successive operations are: finding the calling line; connecting to it a switching circuit; connecting to the operating brains; and indicating readiness to serve.

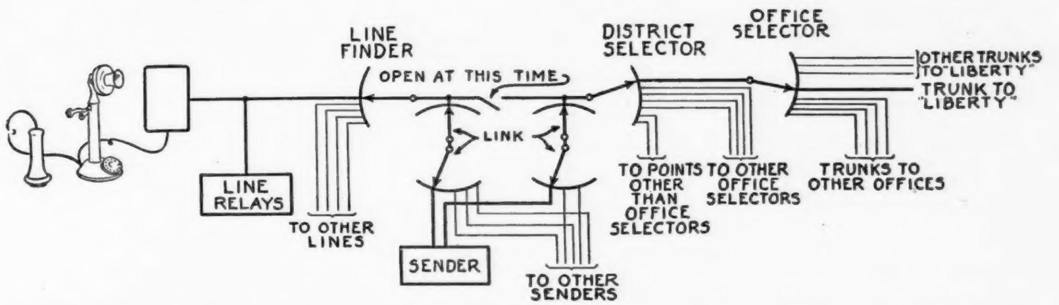
Similarly in the panel-type system the first operation is to find the calling line; and this is done by a "line-finder." It locates the line and also connects to itself a so-called "district selector," which corresponds somewhat to the operator's cord, and a

**Her operations, which should be understood to appreciate machine methods, were described in the* Record *(March, 1925, p. 241), in an article on telephone signalling.*

"sender," which is the brain of the system. The latter corresponds to the operator; as soon as it is connected to the calling line, an operation which usually is completed before the subscriber can lift the receiver to his ear, it places a characteristic tone on the line—the "dial tone," which is the equivalent of "Number please?".

To communicate his desires the subscriber uses the "dial" on the base of his telephone set. He dials seven successive times, selecting each time a finger-hole according to the listed designation of the telephone which he is calling. There are ten possible selections, corresponding to the digits from 1, which causes the least, to 0, which causes the maximum rotation. As the dial rotates back it momentarily breaks the electrical circuit of the telephone line, once for every tenth of this maximum rotation; and this results in a corresponding number of interruptions of the current flow. On the dial eight of the finger-holes are marked with letters as well as digit numbers, three letters for each digit. He dials first the three distinguishing letters of the central office of the line which he is calling; for example, L I B if the number is LIBerty 4259, which is equivalent to 542-4259.

Since the letter "L" corresponds to the digit "5," as the dial returns it opens the line five times. This registers in the mechanical brain of the distant sender where an automatic registering device takes five steps. While the subscriber is turning the dial to the position of the next letter this register is disconnected from the line and a second one is connected. During the return of the dial the second register records "4." In a similar manner each letter and the four digits are recorded each on an individual register.



How various pieces of apparatus have functioned to carry the call through to the outgoing trunk line

In actual operation, recording the designation of the called line in the brain of the sender occupies about ten seconds; and in the meantime, like the human operator whom in these operations it replaces, it is busy with additional matters. As soon as she has learned the office which a subscriber is calling she proceeds to set up a connection with it. Since, however, the telephone plant is constantly enlarging and improving, and offices and trunk circuits are being changed, it may be necessary for her to consult a printed routing-chart of instructions as to how to reach the particular office.

A similar operation must be performed by the mechanical brain of the sender, but since it cannot read print it obtains its information me-

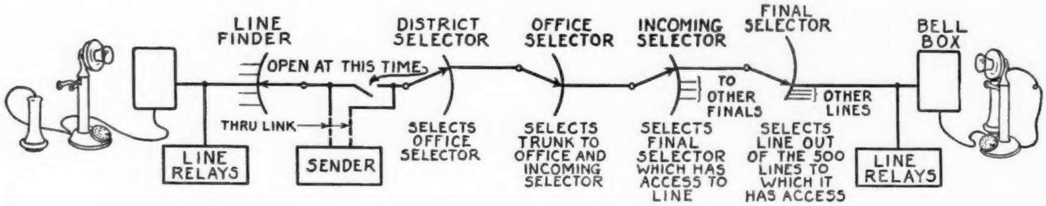
chanically and electrically by consulting a routing-guide known as the "translator." How it does this, is one of the many interesting stories of panel-type operation. Its consultation, however, requires less than a second and then the connection with the called office proceeds. This requires the use of the "district selector" which, it has been stated, corresponds somewhat to an operator's cord and has from the beginning been associated with the line-finder and the sender.

The district selector immediately finds another device known as the "office selector." Offices are grouped into districts and the trunks to them are correspondingly grouped. The district selector, therefore, deals with the proper group and makes a connection with a selector which can select a trunk to the called office. Like a human operator this "office selector" makes a busy test on the trunks to the desired office, seizing the first one which is not busy. A connection is, therefore, quickly established from the sender, which impersonates the operator, to the desired office.

While these operations have been going on the subscriber has continued dialling and usually has just finished so that the complete number of the called telephone is on record in the mechanical brain. There remains the selection of this telephone under the direction of the sender. This is accomplished by the equipment at the called office, that is in the illustratory case, LIBerty.

At this office there is attached to the end of the trunk line an "incoming selector" which takes the first step in the process of obtaining the line of the called subscriber. The last step is taken by a so-called "final selector" which is capable of selecting any of the five hundred lines over which it works. The incoming selector, therefore, puts to work an idle final selector which has access to the lines numbered 4000 to 4499. And this, under the direction of the distant sender, finds 4259, the required line. Having done so it tests to see if the line is busy; and if it is sends back to the calling subscriber a message to that effect.

If the call may be put through, there remain two more operations for the mechanical brain to direct. First it tells the district selector, which is associated with it, to complete the connection between the line of the calling subscriber, and the trunk to the LIBerty office, and to provide proper battery connections for talking current and necessary supervisory mechanisms. As soon as this operation of "trunk closure" has been performed the incoming selector at the LIBerty office applies an automatic ringing current to its subscriber's line. When the subscriber answers it cuts off the ringing current and makes



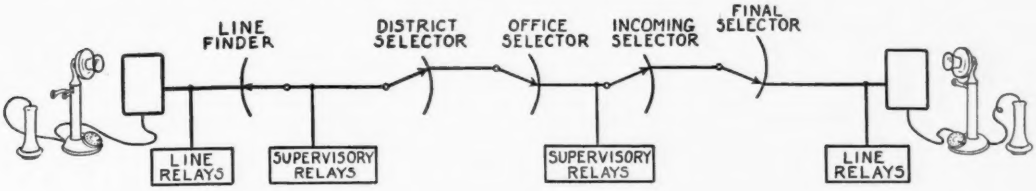
How the connection looks while the called subscriber's bell is being rung

proper connections to a battery for talking current.

The last operation of the sender is to free itself from this circuit which it has set up and to be ready for another incoming call. The whole series of operations which it has performed occupy on the average eighteen or twenty seconds. When the conversation between the two subscribers is terminated, by both receivers being hung up, the various selectors and the line-finder are also released from their functions.

An amazing variety of conditions must be met by this mechanical equipment. How it arranges to do the accounting and handle the cases of unanswered, or of official and free telephone calls; how it operates in the case of coin and pay-station lines; what it does when the called line is busy; how it selects the proper current to ring on party lines—all these are questions the solution of which are as fascinatingly ingenious as the simpler operations which have just been described. The evolution of this panel-type machine-switching system has occupied years, and its story can not be told in any single article.

But the panel type is not the only type of machine switching, nor are all systems so endowed with mechanical brains. Our step-by-step system derives its name from the manner in which it transmits step by step, from one point to another, the controlling actions of the calling subscriber. To him, however, these appear merely as raising the receiver and rotating a dial; but each act is followed by a long train of consequences, mechanically and electrically produced. The sequence of these causes and effects, which results in his desired telephonic connection, although complex in total is understandable in each detail of operation. Both systems deserve and warrant a careful study not only by those concerned with telephony, but by all who are interested in the possibilities of remotely controlling mechanisms.



How the circuit stands during conversation

News Notes

THE INSTALLATION AND TESTING OF APPARATUS for submarine cables has carried several of our engineers far afield. M. B. Kerr left September 3rd for Emden, Germany, in connection with the installing and testing of the apparatus for the Azores-Emden cable. He was joined later by A. B. Newell, who sailed on the 18th of September. J. F. Wentz has recently returned from Nordenham, Germany, where he has been working on manufacturing tests of the Azores-Emden cable. W. A. Knoop returned the latter part of September and W. S. Gorton the middle of October from Penzance, where they had been making tests on the New York via Bay Roberts cable. W. Orvis, who was in London making tests on the southern section of the Pacific cable, returned on September 24th.

DURING SEPTEMBER, D. A. Quarles, R. M. Moody, W. A. Boyd and H. F. Kortheuer were in Hawthorne in connection with the Survey Conference work.

P. B. ALMQUIST, Local Engineer for the Inspection Department at San Francisco, recently visited Los Angeles, San Diego and other Southern California points in connection with inspection problems.

A CONFERENCE on the inspection situation in the Southern Territory, dealing with so-called "Engineering Complaints and Questions," was held in Atlanta on September 27th and 28th. In addition to Southern Bell Telephone and Telegraph Company engineers and representatives of Western Electric Distributing and Installation Departments, R. L. Jones, G. D. Edwards, H. G. Eddy, J. A. St. Clair and J. K. Erwin were present from the Laboratories.

J. A. ST. CLAIR is now Local Engineer for the Southern Territory with headquarters at Atlanta, succeeding J. K. Erwin, who comes to New York for special assignment work in the Field Engineering Force of the Inspection Department.

PROFESSOR R. WHIDDINGDON, F. R. S., Cavendish Professor of Physics and Dean of the Faculty of Sciences in the University of Leeds, addressed the Colloquium on September 30 on the subject of "Luminous Discharges in the Rare Gases."

D. T. MAY has been appointed a member of the Committee on Electrical Protection of the American Railway Association. This committee deals with the protection from harmful voltages of the communication lines of the railways.

J. P. MAXFIELD leaves our technical staff on November 1st to become Manager of Development and Research in the Victor Talking Machine Company. His appointment is not only a further recognition of his contributions and abilities but also indicates the cordial relations of the two companies concerned, since he was suggested by the Laboratories for the position in response to a request from the Victor Company for a suitable nomination.

Saving by Swaging

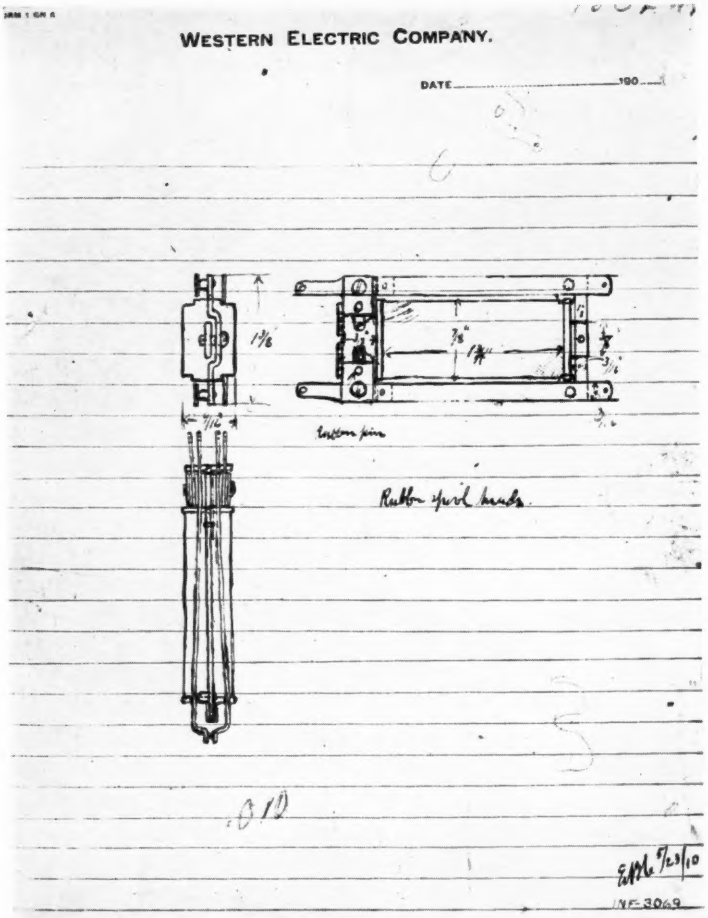
By E. D. MEAD

THIS is not a story of personal saving, although "swaging" may be the process to apply to one's expenses if they are to be shaped to his future needs. The saving is made in copper and its possibility was first demonstrated in our Laboratories by squeezing a flat piece of iron in a vise. This was done about five years ago and today, by conservative estimate, the resulting process saves the Bell System Companies about $250,000 per year. This particular saving is only one of a whole series, for the complete story starts in the early days of telephony and the story is that of the "swaged-core flat-type relay"—with the emphasis on "core".

In the early telephone art the relays were cylindrical in shape. The magnetic circuit was formed by three or more parts: first, there was a core which carried the winding, then an L-shaped piece, and finally, the moving part or armature which completed the magnetic circuit except for the small air-gap. The core was invariably made from a round piece of rod and required in manufacture relatively expensive screw-machine operations. In some cases the return circuit for the magnetic flux was formed by two of the L-shaped pieces and in others by a cylindrical shell which required difficult drawing operations in its manufacture. The armature was usually attached by a trunnion bearing, or by a knife-edge bearing. There was also practically no uniformity in methods of mounting the various types of relays or in the space which they occupied.

With the development in 1910 of Mr. Craft's basic design of a flat-type relay there started enormous improvements in manufacturing processes and in uniformity of sizes of relays and in consequent economies. The magnetic circuit of this relay is formed by two flat pieces which are punched from sheet metal and are therefore of economical manufacture. One of these constitutes the core and terminates at one end in a wide rectangular portion where there are holes for mounting contact springs and lugs for attaching the relay to a mounting plate. The other part is a U-shaped piece with two arms which act as the return path for the magnetic flux while the bottom of the U acts as the armature. These parts are held together by a simple reed hinge which is riveted to the open ends of the U piece and clamped to the rectangular portion at the end of the core. The accompanying pictures show the essential parts of such a relay and also the original sketch of Mr. Craft's design.

This flat-type relay, formed by punchings, has several advantages over the cylindrical relay. Its magnetic parts are reduced in number and simplified in method of production. It may be used to operate many different arrangements of contact springs. Its design also permits mounting ten or twenty in line on a



Mr. Craft's original sketch embodying his invention of the flat-type relay

single strip of metal plate. This strip also is conveniently made by punching. Over such a strip of relays a dust-proof cover can be placed. The economy of mounting space which this design permits has been of constantly increasing value as the complexity of the telephone plant has grown.

Although the flat-type relay was an enormous improvement in many ways over the cylindrical relay it has one disadvantage in that the section of the core on which the winding is placed is flat and rectangular. It takes more wire to go around a rectangular shape than around a cylindrical shape of the same area. The disadvantage inherent in a rectangular core-section was recognized but was more than counter-balanced by the other advantages. It was obvious that a more economical relay would result if the designer, while retaining all the advantages of the flat-type and of manufacture by punch presses could have a round core on which to wind.

Placing one of the flat-core pieces in successively different positions in a vise and squeezing it demonstrated, as was said, the possibility of an easy production of a round core without sacrifice of the other characteristics due to flatness.

In the manufacturing process the transformation of the flat punching into the round-core form is accomplished by holding the ends of the core in a suitable clamp while swage dies in a punch press squeeze the portion of the flat core which lies between the spoolheads into the desired rounded section. The swaging operation performed while the material is cold sets up strains in the iron which are relieved by the annealing operation to which all the magnetic parts are subjected before being finished and assembled in the relay.

The swaged-core relay is known as

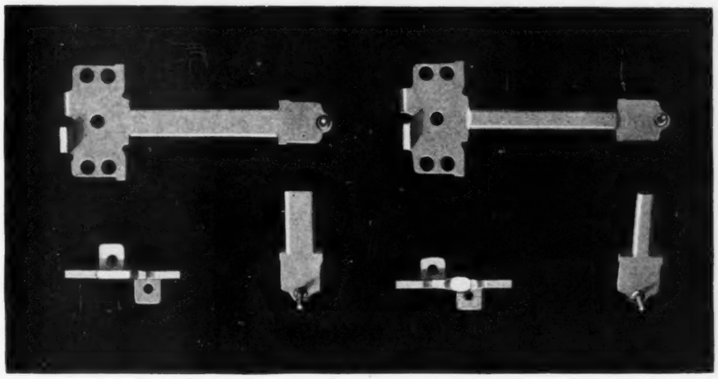
the "R" type to distinguish it from the previous standard "E" type. The shape of the core is changed but not the amount of iron, so that the performance characteristics of the "E" and "R" type relays are the same.

While the iron section of these two types of relays is the same the periphery or distance around the swaged-core is three-fourths of that of the flat type. If the wire is removed from an "E" type relay and rewound on an "R" type it will go around one-eighth more times. Considering that the same current is flowing in each relay there will be an increase in the ampere-turn driving force of the "R" type relay due to the increased number of turns, and it will therefore operate heavier spring loads for the same power consumption.

Another advantage arises because with the reduced periphery of the "R" type relay cord a shorter length of a smaller size of wire can be used to obtain the same number of turns and resistance as on an "E" type relay. This results in a saving of copper wire which on an average amounts to two cents per relay—not much in itself but when multiplied by hundreds of thousands the total saving is appreciable.

The swaging operation effects still another improvement by increasing the height of the winding space. The "E" type relay was designed to mount on 1¾-inch vertical centers; and that establishes the distance between the core and springs available for winding. By comparing the two cores illustrated it is readily seen that the swaged core is not as high as the flat core and there is therefore more winding space available. Now if an "E" and "R" type relay are wound full of the same size of wire the "R" type relay with its larger winding space will have more turns and a longer length of wire. The resistance will be considerably increased and the current for a given voltage will be reduced. Consequently the power required to operate the "R" type relay will be reduced and a saving in annual operating charges will result.

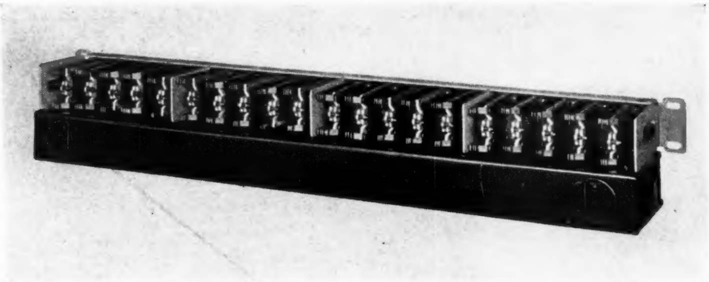
All these benefits of the swaged core are those of operation of the relay. The manufacturing process is also greatly improved because the winding operation is much easier with a round than with a flat core. In winding a flat core the wire is intermittently slack and tense, which tends to stretch the wire. Moreover, the sharp corners may at times damage insulation on the wire. Elimination of these difficulties by use of the swaged core reduces the number of defective coils and speeds up the winding operation. Against these



Relay cores: left, the original flat type; right, the swaged type

economies, the cost of the additional operation of swaging is negligible.

This simple improvement in the design of the flat punched type relay has been readily applied to other types of relays besides the "R" type used as an example above. Moreover, the swaging operation is not limited to magnetic iron; it is being used in connection with two grades of permalloy. And so an improvement initiated by the squeeze of a vise has culminated in squeezing out each year a quarter-million dollars' worth more of relays from an equivalent expenditure of materials and labor.



Twenty relays in nineteen inches: a group arranged for mounting on vertical racks

To entertain Queen Marie of Rumania and her party, a Western Electric radio receiving set has been installed at the request of the American Telephone & Telegraph Company on the special train in which Her Majesty is touring the United States. The equipment was constructed in the Laboratories, and embodies the latest developments in radio reception, amplification and sound projection. Its exterior matches the decorations of the observation car. It is in charge of P. H. Betts of our radio development group.

How the P. B. X. Gets Its Power

By ROBERT L. LUNSFORD

THIS is the story of the development of an automatic power plant for Private Branch Exchanges and for certain types of small central offices. The essential difference between a telephone central-office and a private branch exchange is disclosed by the word "private". To the switchboard of a central office are connected lines from all the telephone subscribers of the immediate neighborhood which can efficiently be served from that switchboard. Interconnection between their lines is accomplished at this board, and other desired connections are made made over trunk lines to other central offices. The various subscribers who are connected to the central office form a geographical unit.

In the case of the P.B.X., however, the individuals to whom lines extend from the board may or may not form a geographical unit, but always are members of the same corparate unit; or the P.B.X. is a switchboard for the interconnection of the various telephones of a business or social organization, or of the rooms of a hotel or club. Its trunk lines running to one or more central offices of the Telephone Company correspond to and serve the same purpose of outside connections as do the ordinary lines from any subscriber to his telephone central-office.

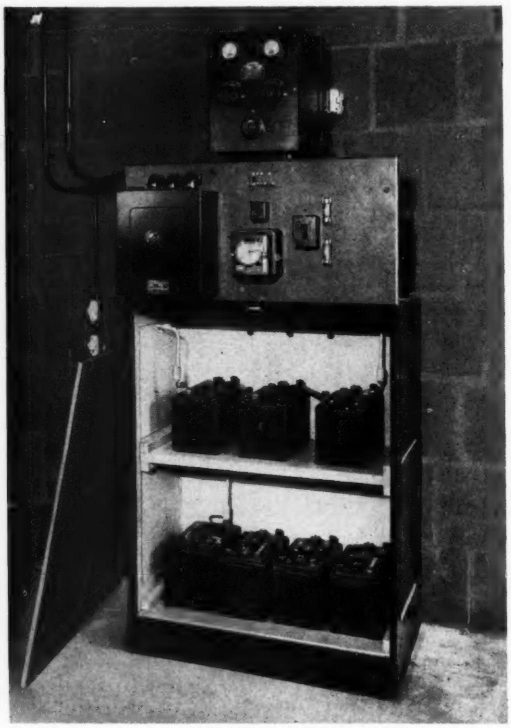
The requirements for electrical power, however, for the single subscriber, and for the subscribers of a P.B.X. service are quite different. The ordinary telephone subscriber needs no source of power on his premises because the batteries which send the signal current when he lifts his receiver from the hook, the generator which rings to attract his attention, and the battery supplying the current which his transmitter modulates, are all located at the central office to which he is connected. At a private branch exchange, on the other hand, because it serves to interconnect a number of telephones, there must be available for signalling, talking, ringing, and similar operations, a source of power which is essentially equivalent to that of a telephone central office. In magnitude the power requirements of a P.B.X. are not those of the larger central office, but in reliability and all the standards of uniformity they are the same.

Two general methods for supplying power to the P.B.X. are therefore possible: either to install power equipment or to obtain the power by transmission from the telephone central office. The latter method is obviously highly inefficient and requires the assignment for that purpose of extra telephone conductors; but it is a method which is practicable and has been widely used. The installation of power equipment has its elements, also, of inefficiency, since the requirement of reliability involves the purchase and operation of motor-generator equipment similar to that used in

the large central office. The actual size and cost depend upon the number of telephones to be served.

What is desired, therefore, is a battery-charging equipment which is automatic, requires only occasional inspection, and operates from a lighting circuit or other commercial source of alternating current.

One of the early attempts to provide such equipment made use of mercury-arc rectifiers for adapting the alternating-current to the charging of the batteries. As a storage battery becomes exhausted its voltage falls. A volt-meter relay and associated control equipment was therefore provided which would connect the charging equipment to the battery when the voltage fell below a specified value.



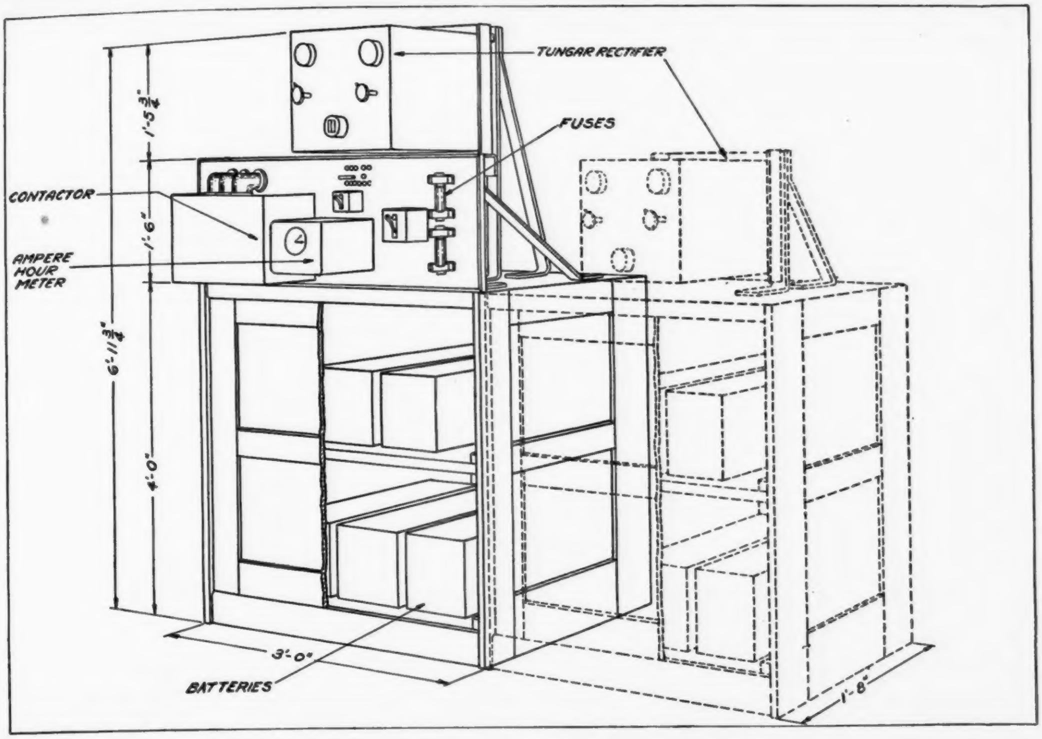
A trial installation of battery charging equipment in our Laboratories

Experience with this automatic equipment developed an unsatisfactory characteristic of the voltmeter-relay method. When, for example, the drain on the batteries is gradual, as may happen in a small exchange, they may become very much exhausted before their voltage falls sufficiently to operate the relay; the result then is that the charging equipment does not have time to recharge sufficiently before a serious effect is encountered. There was also another disadvantage to this system in its requirement of counter-E.M.F. cells and special switching equipment to keep out of the switchboard circuits the charging current from the rectifier.

In the redesign of the automatic power-plant the Tungar rectifier, widely and popularly used for charging storage batteries in radio receiving sets, offered certain advantages. The first important step in the design was the recognition, and verification by experiment, of the fact that the logical control was an ampere-hour meter with relay contacts arranged to start and stop the rectifier. This method of control had in fact been tried before but at the time it lacked certain characteristics which were essential to P.B.X. service.

The present solution of the problem is an automatic charging-system making use of the full-wave tungar rectifier. It is suitable for manual P.B.X. boards such as the No. 600 and No. 604 and the No. 700 machine switching board; it is also suitable for use in small central offices with the No. 109-A magneto and the 9-C common battery board.

An ampere-hour meter is in effect a small direct-current motor with a permanent-magnet field, through whose armature passes the current to



A complete telephone power plant in outline; solid and dotted lines show, respectively, the initial installation and an addition

be measured. The total number of revolutions in any time is a measure of the quantity of electricity (ampere-hours) which has passed. This meter is connected in series with the storage battery. A pointer geared to the rotating shaft indicates the state of charge of the battery; rotating with the pointer, but adjustable with relation to it, is a cam. When the battery is discharged, the cam closes a spring contact which energizes the "start-charging" relay. The relay locks up through one of its own contacts under control of the "stop-charging" contact on the meter; and at the same time it operates a contactor in the power line, closing the power circuit through the rectifier. When the battery is fully charged, the cam breaks the "stop-charging" contact which opens the locking circuit of the "start-charging" relay. The latter in turn releases the contactor in the power line and shuts off the power.

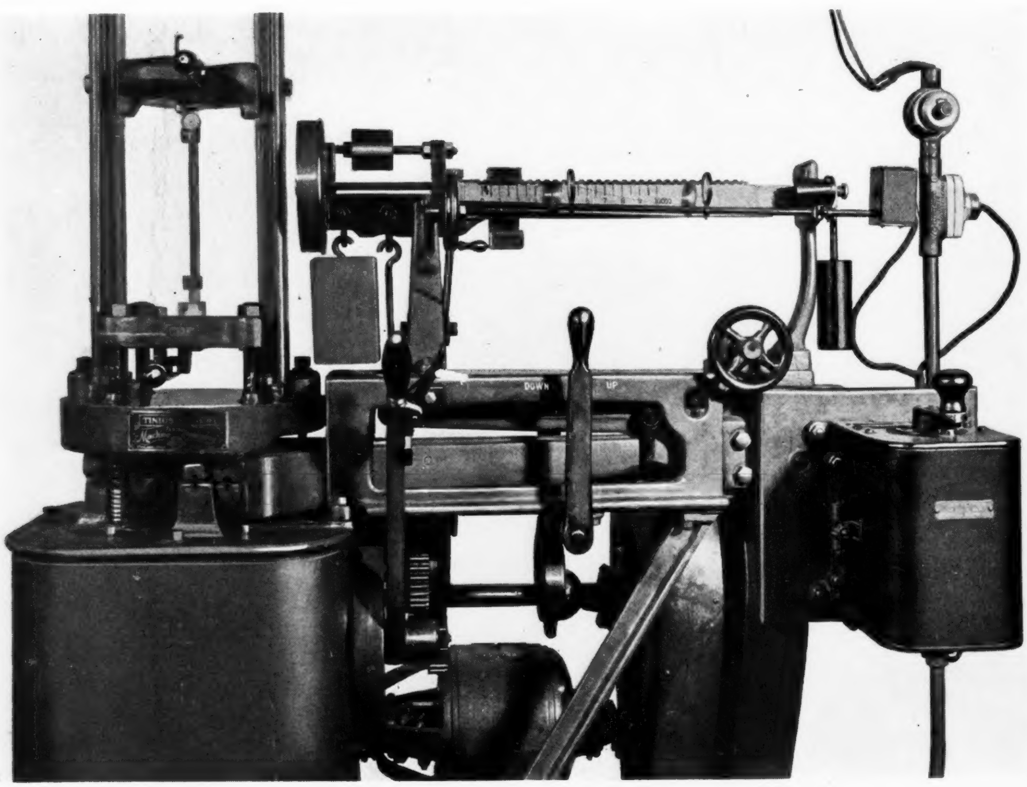
An alarm has been added to the operating features to provide warning in case of the failure of power or of the Tungar bulb. Thus, if the meter-cam continues to move in the "discharge" direction after closing the start-charging contact, a second contact is made which lights a lamp and rings an alarm bell. A snap-switch and relay permit the alarm bell to be put under control of the rectifier circuit so that the alarm will ring as soon as the current comes on again.

Alarm signals are also provided to indicate a blown fuse or other failures. All of these signals may be transmitted to the nearest central office, whence an attendant may be sent to clear the trouble. In addition, it

should be necessary for a power man to visit the plant only for a few minutes about once a week to check the gravity and voltage of the batteries.

Among considerations in the mechanical design of the equipment were adaptability to mounting either on or above a battery cabinet, or on a standard relay rack; ease of access for adjustments; addition of other units to care for growth, and applicability to switchboards of a variety of types. To provide ringing current, a small motor-generator set is available. This is carried on a panel to which it is attached by a jack-and-plug mounting. If this machine becomes defective it may be replaced quickly by a spare.

Such a plant as this has been in constant operation for nearly a year on the seventh floor of our Laboratories, supplying power for a machine switching P.B.X. which is under test in the laboratory. No trouble whatever has been encountered with it and its installation bears out the economy of operation and reduced maintenance charges which have been expected.



A 10,000-*pound tensile testing-machine. Force exerted on the sample* (*left*) *is measured by its reaction on the scale beam*

A Modern Inquisition

By W. S. HAYFORD

IN the good old days, it was an easy matter to get evidence from an unwilling witness. Traditions, clustering mostly around the Spanish Inquisition, tell us that tongues were loosened by stretching their owners on a rack, or pressing them under heavy weights. What the victims said was usually what they thought their inquisitors wanted to hear, be it the truth or not. Here in the Laboratories some of our equipment differs from its medieval prototypes only in refinement of detail and its use to determine, not the past of flesh-and-blood, but the future of steel, copper and alloys.

Mechanical properties of materials are naturally of fundamental importance in design. A great deal is known in general about how metals behave when they are pulled, twisted, squeezed and hammered, but special questions are continually being put to the group in the General Development Laboratory which is equipped with ingenious devices to help it find the answers from various materials.

The Schopper tester for light tensile tests such as cable-paper and materials for transmitter diaphragms

In its "torture chamber," scientific counterparts of the medieval racks are the tensile testing-machines designed to accommodate all sizes of material. To insure reliable testimony the metal is cut in a long strip with very carefully shaped and smoothed edges. Steel jaws firmly clamp the sample and it is slowly stretched until its very crystals creak. Since metals do not speak our language an interpreter in the form of an extensometer is necessary. This is responsive to the slightest movement; and a stretch of a ten-thousandth of an inch is registered. The testimony desired is that of its stubborness in resisting, and, of the force below which the metal resists with might and main, and above

which only its inherent tenacity opposes further stretching. Up to this force, called the elastic limit, increases in load cause proportional increases in length. After it has been passed small additions in load mean large increases in length until, finally, the metal breaks.

What information do these values impart? The stubborness or, as it is technically called, the modulus of elasticity evaluates the stiffness which varies greatly for different materials. Steel, which is twice as firm as brass or bronze, is the most rigid of commonly used materials. In fact, it is sometimes necessary to use 200,000

This Rockwell hardness test presses a steel ball into the sample

pounds pull per square inch to break a steel bar. Soft materials—copper, lead and the like—surrender without a struggle. The elastic limit is a measure of the maximum force which can be applied without deforming the metal. If the material is to be used as a spring it is an indication of the deflection that can be given, and still have the spring return to its original position when the force is removed. A break only occurs after the elastic limit has been passed, and considerable deformation has taken place. The minimum force required to break a specimen is a measure of the load which its material can be counted upon to carry.

Another form of evidence is obtained by placing on the sample marks, which are one inch apart before stretching, and after the test, measuring the distance between them. The elongation is a measure of the ductility, which determines how well the metal will stand bending or stretching in the forming and stamping operations of manufacturing.

If in the olden days it was desired to shatter the nervous system of a victim, water was allowed to drip slowly upon his head. Each drop was inconsequential in itself, but the succession of small blows finally caused collapse. Similarly, stresses below the elastic limit may be applied to a metal for a few times with perfect safety,—but if this is repeated a large number of times a rupture starts at some weak spot, and spreads until complete breakdown occurs. This deterioration is called fatigue. To evaluate it the metal is bent back and forth until broken. Many of us have applied this principle, probably unawares, when we have broken a piece of metal by repeated bending. A knowledge of this property is valuable in determining the fitness of parts to encounter millions of operations during their life.

Whenever less expenditure of time

and effort is desired, several tests are used which do not severely damage the sample. One of these is the hardness test, which is made in two ways. In one a steel ball or diamond cone is pressed with a definite force into the specimen, and the depth of indentation measured. In the other—using the scleroscope—a small hammer falls, strikes the material, and rebounds a distance proportional to the hardness. Since these tests are not destructive they can often be made on finished parts, and the results correlated with tests made on the tensile machines.

Rapid, also, is the ductility test in which is measured the amount of stretching a sample will endure. The metal is placed across an opening into which is pushed a steel ball. This forms the metal into a cup, and it has to stretch as the cup deepens. The More ductile the material, the deeper will be the cup before breaking.

In all these tests the metals are carefully prepared, and examined as to their shape and dimensions. Great refinements in measuring are used to insure accurate data. An error of less than one percent is set as the standard, and for this degree of accuracy a Zeiss "Optimeter," and a "barrel" micrometer are employed. The first, measuring to within one one-hundred-thousandth of an inch, is a combination of an optical and a mechanical system, an optical micrometer; the latter is an ordinary micrometer with a greatly enlarged barrel, which permits a larger number of divisions, and, thereby, greater precision.

It has been aptly remarked that experiments are merely controlled experiences—controlled so that only the factors whose effects are to be studied have any bearing on the tests. These material tests, which, by the way, were among the first methods used to determine fitness, are good examples of controlled experiences, for all factors, except those desired, have been eliminated. They do not, as did the tortures of the Inquisition, reveal the past; but, instead, are excellent criteria of future behavior.

The scleroscope—another type of hardness tester

The Transmitter Life-Test

By ARTHUR W. HAYES

As you make a telephone call, do you ever think of the variety of conditions the transmitter must endure? Most telephone users probably never give a thought to the reactions in a transmitter when its position is altered, or when it is jarred by slamming the receiver onto the hook. Anticipating such conditions is a major activity of a group of engineers in our Laboratories. The transmitter life-test was developed as an aid to their work.

As is true of most things, the user to a great extent determines the length of satisfactory service for a transmitter. Its life might extend almost indefinitely, but unfortunately sufficiently considerate treatment is rare. The transmitter is subject to all possible positions and to careless handling. Since this will always be, the transmitter must be designed to meet the conditions; and the life test, which ascertains just how well it will do so, emphasizes the extremes of service conditions.

Exigencies of the development work on transmitters require that in the space of a few weeks there be collected information which would normally be disclosed only throughout the entire and actual life-span of a transmitter in service. If the mechanism between cause and effect were always fully understood, it might be possible to duplicate effects without exactly duplicating causes For the carbon transmitter, this is impracticable; so the life test must simulate service conditions except that there must be continuous, instead of occasional, operation.

For this there is not needed a complete telephone system, with all its ramifications. The life-test plant need include only those features which have direct bearing on the behavior and life of the transmitter, such as the equipment and battery of the cord and subscriber's circuit. In the telephone operation two important and variable factors are the battery voltage and the length of circuit. These, with the transmitter's own resistance, determine the current flowing through it and thus indirectly, its useful life. Provision is made, therefore, for varying these factors independently; and in addition the flexible arrangement of equipment permits simulation of other field conditions.

The transmitters are mounted on large frames which hold also the other circuit elements and the relays for switching the transmitters in and out of circuit. In front of each mouthpiece is suspended a receiver which is the acoustic driving force, agitating the transmitter diaphragm as would actual speech. The transmitters are alternately in and out of circuit with the period in circuit approximately that of an average telephone call. On the lower portion of the frames are provided jacks into which meters may be plugged for periodic measurements of the transmitter resistance, an important factor in its operation.

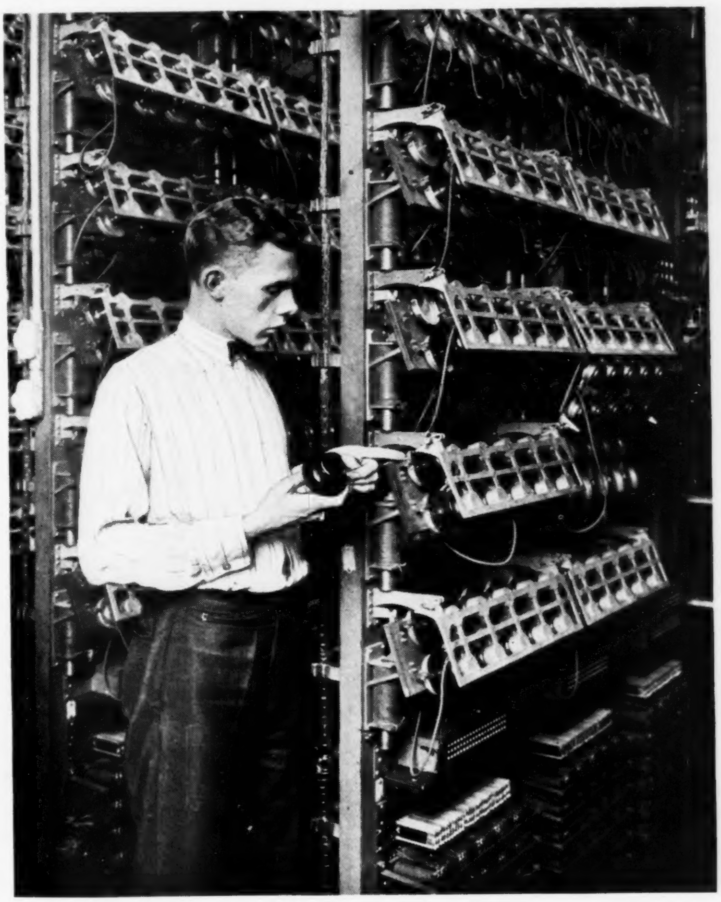
It is desirable in the test to employ

the sounds of speech and these are provided by a special phonograph developed in the Laboratories. The record reproduces two sentences like, "Joe took father's shoe bench out," and "She was waiting at my lawn." Obviously with no meaning, such sentences are simple combinations of those speech sounds which contribute most appreciably to loudness. The receivers are connected to the phonograph, through an amplifier, and deliver to the transmitters a volume of sound equal to that of ordinary conversation. To the phonograph itself is attached a sequence switch which controls the switching of the transmitters and receivers and the operation of the other devices.

To simulate the shocks which may be received by the deskstand transmitter, the instruments under test are jarred by hammers, magnetically controlled, which strike the backs of their mountings while the circuit is open.

The life test is automatic and continuous; duplicate apparatus is provided where failure is apt to occur. The present plant is equipped to test over 500 transmitters under ordinary room conditions and sixty under conditions of controlled humidity and temperature.

Fifty-four hundred calls of two minutes each would constitute an average year of service for a deskstand transmitter. In the test plant the equivalent of this service is fifteen days. How many such equivalent years of service constitute a life test varies with the type of transmitter and the class of service. Before the transmitters are placed on test, and periodically during the test, measurements are made of various characteristics from which the rate of ageing of the instruments is determined. Data fundamental to future improvement are obtained thus, and from the rate may be judged how well any transmitter would have served practically in the art of communication.



F. E. Engelke points out the place of the transmitter in the testing system

The Life of a Pioneer

By J. S. HARTNETT

WHEN a man has lived to see some measure of his footprints in the sands of his own time, and proceeds simply and straightforwardly to set down the record of his life and work, we should have an engrossing book.*

Thomas A. Watson records his life with engaging humility. "I cannot begin this story of my life with an account of distinguished ancestors," he says in his first sentence. Thence he traces the various tendencies of his boyhood, bound by the natural and imposed restrictions of Salem of the 1860's. Discernably he early acquired a large respect for nature and knowledge which his part in the invention of the telephone only increased. He felt himself always a seeker, a student.

Several chapters of Mr. Watson's book are naturally given to the history of Bell's invention. He describes in turn Bell's struggle to bring to being his conception of a "voice shaped electric current," the repeated elusiveness of result, the lecture tour necessary to convince the public that the result was workable, the establishment of a market for the telephone, and when the "toy" was seen to be a symbol of fame and financial return, the extended patent litigation which ensued. This is a story that has often been told but is refreshingly new and first hand from the pen of the man who in 1876 for the first time heard instrumentally a voice in the next room; and in 1915, through the development of the same instrument, the same voice across a continent.

Similar space is given to the second phase of Mr. Watson's industrial career: shipbuilding. Retiring after a few years of telephone activity to the cultural pursuits earlier denied him, he soon found that an active brain must have supplement in active hands. The industrial development of his home State then appealed to him. The rapidity with which the little machine shop which he had set up on his farm for his own pastime expanded into a large plant for the manufacture of engines and at the turn of the century became one of the largest shipyards in the country, is an exciting account of what American industry can be when there is a will behind it. Two destroyers then built saw service in the World War.

Color pervades the book: a richness of incidents, thoughts, persons and places. The reader travels from Alaska to Egypt; from East Braintree, Massachusetts, to Monte Carlo. Its people range from Billy Egan who washed cabs to the Prince of Wales who became Edward VII. There are discussions of geology, socialism, Emerson, English lodgings, poetry, gold mining, kindergartens. And the author recounts with mel-

*EXPLORING LIFE. THE AUTOBIOGRAPHY OF THOMAS A. WATSON. *New York-London. D. Appleton and Company.*

lowed amusement how he once shrieked into the mouthpiece of the new telephone the words of the old vocal warning "Do Not Trust Him, Gentle Lady" in order to impress a New York audience to which Dr. Bell was explaining his invention.

The book is timely, following so closely the fiftieth anniversary of the telephone. It contains no pretense of technical description or literary style, although by its very simplicity it frequently achieves the latter. Rather is the book in essence a modest, philosophical and often humorous telling of the career of a man who has seen many things and could yet at the age of fifty-five join the ranks of a traveling band of Shakespearian players in order that he might further study the culture of voice and mind. An exploration of life, indeed.

In The Month's News

AUDIBLE motion picture equipment was installed and demonstrated at the Conference of Presidents of Bell System Companies at Yama Farms during the first week in October. H. B. Santee, R. E. Kuebler, J. P. Maxfield and D. G. Blattner were the experts responsible for the demonstration.

W. V. WOLFE spent several days in Chicago and Minneapolis in connection with the power-line carrier situation of the Northern States Power Company.

HELEN M. CRAIG of the library staff attended the annual convention of the American Library Association at Atlantic City, October 4 to 7.

FRANCIS F. LUCAS presented before the convention of the American Society for Steel Testing at Chicago on September 20th a paper on "Observations on the Microstructure of the Path of Fatigue Failure in a Specimen of Armco Iron."

AN INTRODUCTION TO "CONTEMPORARY PHYSICS," by Karl K. Darrow, has just been published by D. Van Nostrand and Company. It describes and interprets some of the phenomena of electronic physics, following the general lines of his recent series of articles in the Bell System Technical Journal under the title "Some Contemporary Advances in Physics."

D. H. WETHERELL AND E. H. SMITH have visited Springfield, Massachusetts, several times in connection with the first installation of step-by-step equipment manufactured at Hawthorne and using the new high frames.

DEVELOPMENT of a tandem switchboard arranged for straightforward operation recently took R. J. Miller to Hawthorne.

W. L. DODGE AND R. G. KOONTZ have been at Hawthorne for several weeks studying manufacturing methods on wiring and testing.

J. C. BURKHOLDER is now in Canada to place carrier-telegraph equipment in service on the lines of the Canadian National Railways.

J. H. BELL AND G. C. CUMMINGS were at Washington investigating the trial installation of the differential duplex open-wire repeaters now op-

erating between that city and Atlanta.

WATERTOWN AND SYRACUSE, NEW YORK, are now connected by a D-1 single-channel carrier system, which is being tested by C. L. Weiss, A. Dickieson, and H. S. Black.

HENRY HOVLAND, who has handled several consolidations of step-by-step systems has recently been concerned with such problems in Grand Rapids and Columbus.

THE FIRST INSTALLATION in a step-by-step exchange of the cordless "B" system called J. L. Dow, W. J. Lacerte and L. D. Plotner to Mckeesport.

F. R. MCMURRY spent about two weeks in Chicago at the Morkrum-Kleinschmidt Corporation, where he dealt with problems of printing telegraph manufacture and development.

R. L. JONES AND S. C. MILLER recently visited Brazil, Indiana, in connection with inspection problems arising in the manufacture of clay conduit.

P. A. ANDERSON has returned from Sao Paulo, Brazil, where he was supervising the installation of a No. 106-A Radio Telephone Broadcasting Equipment.

W. B. DAVIS is supervising the installation of a one kilowatt broadcasting equipment for the Churchill Tabernacle in Buffalo.

H. B. DEAL is carrying on a series of antenna investigations at the Whippany laboratory.

PREPARATORY TO THE INSTALLATION of a fifty-kilowatt broadcasting equipment at Whippany, R. E. Coram, W. L. Black and R. H. Freeman are engaged in experimental work there.

J. M. FINCH AND W. C. REDDING recently made an inspection tour of the Hollingsworth-Vose paper mills at East Walpole, Massachusetts.

J. E. HARRIS AND J. R. TOWNSEND attended the September meeting of American Society for Steel Treating in Chicago.

R. R. WILLIAMS AND H. T. REEVE recently visited the Laboratories of the General Electric Company at Schenectady.

J. R. TOWNSEND AND W. G. KNOX attended the autumn meeting of the Electro-Chemical Society in Washington during October.

SERGIUS P. GRACE has written an article on "Science and Research in Telephony" for the magazine "Telephony."

ABSTRACTS OF PAPERS by Herbert E. Ives and by R. C. Mathes have appeared recently in the "Journal de Physique et le Radium" and "Elettrotecnica," respectively.

THE CALL LETTERS of the Whippany Laboratory, which was described in the October issue, have been changed to 3XN.

DURING THE MONTHS OF AUGUST AND SEPTEMBER United States Patents were issued to the following members of Bell Telephone Laboratories:

C. H. Berry	J. W. Horton (2)
W. W. Carpenter	B. W. Kendall
H. C. Caverly	A. W. Kishpaugh
H. R. Clarke	J. J. Lyng
B. G. Dunham	D. MacKenzie
H. A. Frederick	W. H. Matthies
E. S. Gibson (4)	John Mills
C. L. Goodrum	P. C. Smith
T. R. Griffith	R. L. Stokely
J. E. Harris	C. H. Wheeler

S. B. Williams (5)

As an artist visualizes our workplace

This drawing by V. F. Macom based on photographs taken in several of our laboratories, was an illustration for the souvenir booklet prepared by the Information Department of the American Telephone and Telegraph Company, and presented to the Telephone Pioneers at their recent convention in New York City.

Bell Laboratories Club

Tuesday, 2:	*Hike—Port Washington to Sands Point Lighthouse*
Wednesday, 3:	*Swimming Classes for Women, Carroll Club, 5.30 p.m.*
Thursday, 4:	*Basketball, Men, Labor Temple, 5.30 p.m.* *Athletic Dancing Classes for Women, Manhattan Trade School for Girls, 6 p.m.*
Friday, 5:	*Bowling League, Dwyer's Manhattan Alleys, 5.45 p.m.* *Women's Bridge Club, Rest Room, 5.05 p.m.* *Chess, Restaurant Blue Room, 5.45 p.m.*
Saturday, 6:	*Horseback Riding, Unity Riding Academy* *Chess, Commercial Chess League Tournament*
Sunday, 7:	*Hike: Wanaque to Bloomingdale*
Monday, 8:	*Basketball, Women, Washington Irving High School, 5.30 p.m.* *Symphony Orchestra Rehearsal, Auditorium, 5.30 p.m.* *Men's Bridge Club, Room 269, 6 p.m.*
Tuesday, 9:	*Basketball, Men, Labor Temple, 5.30 p.m.*
Wednesday, 10:	*Dance, Hotel Pennyslvania, 9 p.m.*
Thursday, 11:	*Basketball, Men, Labor Temple, 5.30 p.m.* *Athletic Dancing Classes for Women, Manhattan Trade School for Girls, 6 p.m.*
Friday, 12:	*Bowling League, Dwyer's Manhattan Alleys, 5.45 p.m.* *Women's Bridge Club, Rest Room, 5.05 p.m.* *Chess, Restaurant Blue Room, 5.45 p.m.*
Saturday, 13:	*Horseback Riding, Unity Riding Academy* *Hike: Camp-fire Supper at St. Mary's Lake*
Monday, 15:	*Basketball, Women, Washington Irving High School, 5.30 p.m.* *Symphony Orchestra Rehearsal, Auditorium, 5.30 p.m.* *Men's Bridge Club, Room 269, 6 p.m.*

Calendar for November, 1926

TUESDAY, 16:	*Basketball, Men, Labor Temple, 5.30 p.m.*
WEDNESDAY, 17:	*Swimming Classes for Women, Carroll Club, 5.30 p.m.*
THURSDAY, 18:	*Basketball, Men, Labor Temple, 5.30 p.m.* *Athletic Dancing Classes for Women, Manhattan Trade School for Girls, 6 p.m.*
FRIDAY, 19:	*Bowling League, Dwyer's Manhattan Alleys, 5.45 p.m.* *Women's Bridge Club, Rest Room, 5.05 p.m.* *Chess, Restaurant Blue Room, 5.45 p.m.*
SATURDAY, 20:	*Horseback Riding, Unity Riding Academy* *Chess Match, Commercial Chess League Tournament*
SUNDAY, 21:	*Hike: Tarrytown, Sleepy Hollow and Pontico*
MONDAY, 22:	*Basketball, Women, Washington Irving High School, 5.30 p.m.* *Symphony Orchestra, Rehearsal, Auditorium, 5.30 p.m* *Men's Bridge Club, Room 269, 6 p.m.*
TUESDAY, 23:	*Basketball, Men, Labor Temple, 5.30 p.m.*
WEDNESDAY, 24:	*Swimming Classes for Women, Carroll Club, 5.30 p.m.*
FRIDAY, 26:	*Bowling League, Dwyer's Manhattan Alleys, 5.45 p.m.* *Women's Bridge Club, Rest Room, 5.05 p.m.* *Chess, Restaurant Blue Room, 5.45 p.m.*
SATURDAY, 27:	*Horseback Riding, Unity Riding Academy* *Hike: West Shore of Hudson to Alpine* *Chess, Commercial Chess League Tournament*
MONDAY, 29:	*Basketball, Women, Washington Irving High School, 5.30 p.m.* *Symphony Orchestra Rehearsal, Auditorium, 5.30 p.m.* *Men's Bridge Club, Room 269, 6 p.m.*
TUESDAY, 30:	*Basketball, Men, Labor Temple, 5.30 p.m.*

Club Notes

THE qualifying round of the fall tournament of the Bell Laboratories Club was held on September 11 at the Salisbury Country Club, Garden City, Long Island. Sixty golfers teed off in what was the most exciting of any of the Club tournaments. Prizes were offered for the two best gross scores and the two best net scores. J. Hillier turned in an 84 for low gross and J. A. Burwell came in second with an 88. O. Cesareo's 64 was low net, and O. H. Williford took second low net with a 71.

The twenty-eight players qualifying for the finals on Saturday, September 18, were:

CLASS "A"

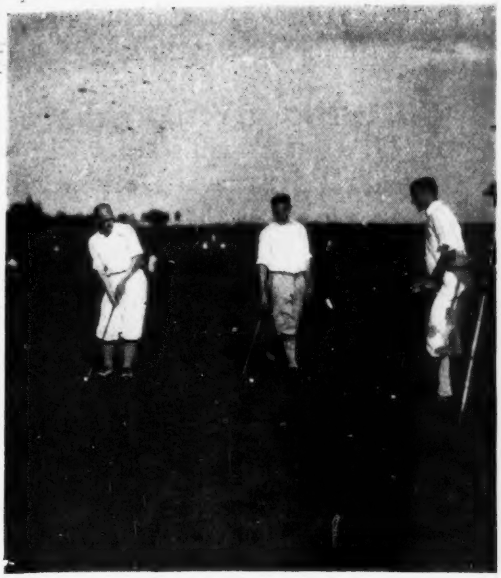
Name	*Gross*	*Net*
J. Hillier	84	72
J. A. Burwell	88	73
G. E. Kellogg	91	79
E. H. Clark	91	79
O. Cesareo	91	64
G. T. Lewis	93	81
W. C. Miller	95	73
H. L. Walters	98	73
A. L. Johnsrud	99	76
R. J. Nossaman	100	78
H. A. Pattison	100	82
A. J. Boesch	101	78

CLASS "B"

Name	*Gross*	*Net*
G. H. Heydt	102	82
O. H. Williford	102	71

A. L. Johnsrud, winner of Club Championship for 1926

A. J. Boesch watches T. C. Rice sink a "birdie"



W. Harvey, L. Hoyt and W. Means

R. J. Nossaman sinks a long approach shot

W. J. Means	103	81
J. A. Lee	104	78
T. C. Rice	105	81
W. Harvey	105	78
G. Degenring	107	78
J. Mallon	109	75
M. R. McKenney	110	83
A. J. Crawford	114	79
T. Ingram	115	80
L. P. Bartheld	116	81
I. W. Brown	116	81
L. N. Hampton	117	82
W. F. Robb	117	82
E. A. Looney	117	82

All the qualifying players were out for the finals on September 18, which was a perfect day for golf as far as the weather was concerned.

Records and clubs were broken, and when all cards were in, A. L. Johnsrud was leading "A" Class, and J. J. Mallon was leading "B" Class.

In addition to the prize offered by the Club, Thomas E. Wilson and Company offered as a prize for the low gross score in the finals, one dozen Harlequin golf balls. G. E. Kellogg carried off this prize with a gross score of 85.

The result was:

CLASS "A"

	Gross	*Hd.*	*Net*
Johnsrud	93	22	71
Nossaman	95	22	73
Kellogg	85	12	73
Burwell	90	15	17
Miller	96	21	75

CLASS "B"

	Gross	*Hd.*	*Net*
Mallon	104	34	70
Degenring	104	29	75
Hampton	110	35	75
Rice	100	24	76
Harvey	103	27	76

The 1926 golf season has come and gone. Some of us believe our game has improved, while others are dissatisfied with their scores for the season. But then, golf is a queer game—one which requires much patience and practice. Always remember that whether your score is good

or bad, you are getting good healthy exercise while tramping over a golf course.

* * * *

BASKETBALL for women will start on Monday evening, November 8, at 5:30 p.m., in the gymnasium of Washington Irving High School. This season the women will be coached by Miss Boynton, Assistant Physical Director of Houston House.

Previous to this year the women's league has been made up of teams representing various departments in West Street, but this year the teams will be organized by Miss Boynton, with departmental lines disregarded entirely. Later in the season a team will be organized to meet women's teams from other commercial houses and clubs in the City. Ellen Kerney, Extension 706, will be glad to tell you more about our plans.

* * * *

EXERCISE, if taken in moderation, is most beneficial to all of us; and with this thought in mind the Club has planned a course in physical training under the direction of expert instructors.

The first half of this course will consist of a series of ten lessons in aesthetic and gymnastic dancing under the direction of Mrs. S. S. A. Watkins of the Noyes School. These classes will be held at six p.m. on Thursday evenings in the gymnasium of the Manhattan Trade School for Girls. The classes will start on October 7 and continue until December 9. The ten lessons cost three dollars.

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Margaret Horne, Publicity Director for the Club

IF YOU are gifted with the ability to design and make posters, you will be interested in a competition that is to be held for the best Christmas Poster. Posters will be judged by a disinterested committee, and one or more of the best will be reproduced for display on the bulletin boards.

Posters should be twelve by sixteen inches, and in not more than three colors. Space should be left for a Christmas greeting, which will be inserted after the poster has been accepted. Contestants should submit their designs to D. D. Haggerty not later than December 1, 1926.

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ON WEDNESDAY EVENING, November 10, in the Grand Ballroom of the Hotel Pennsylvania, the Club will hold another one of its now famous dances. Ben Bernie will provide the music, and if you attended our last dance, on April thirteenth, you know what a pleasure it was to dance to the spirited music of this master of modern "jazz."